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BIOLOGY
HIGHER LEVEL
PAPER 3

Candidate session number

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Thursday 17 November 2011 (morning)

1 hour 15 minutes

Examination code

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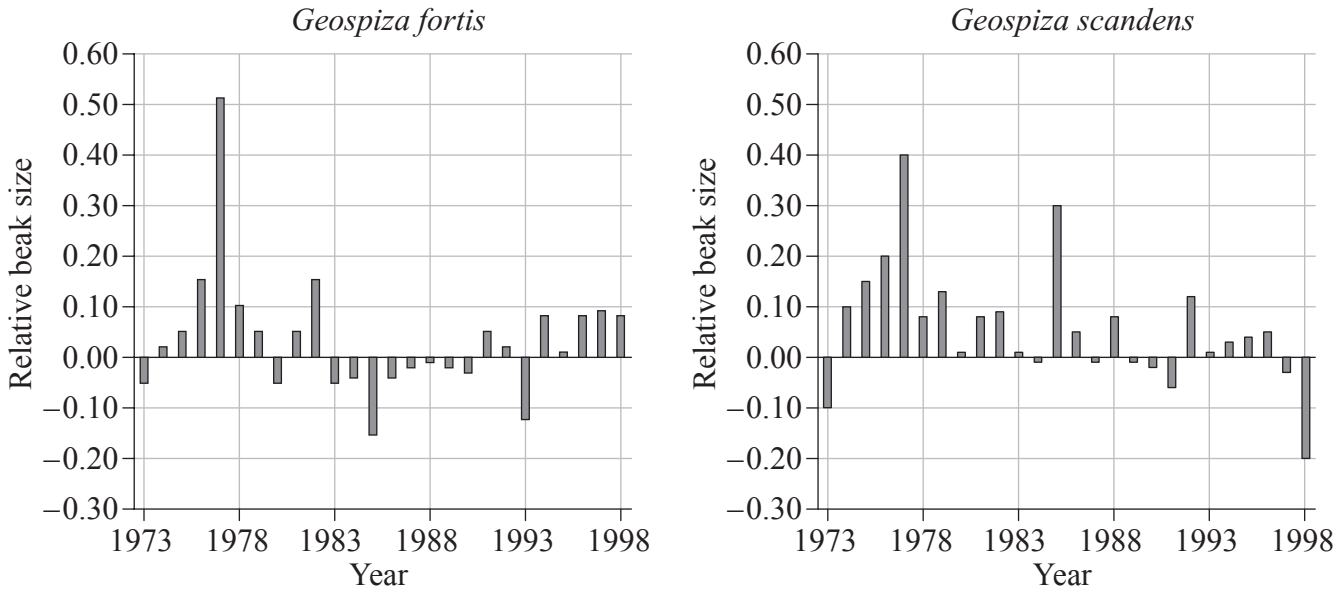
INSTRUCTIONS TO CANDIDATES

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Answer all of the questions from two of the Options.
- Write your answers in the boxes provided.

Option D — Evolution

D1. A study of two populations of Darwin's finches, medium ground finch (*Geospiza fortis*) and cactus finch (*Geospiza scandens*), was undertaken between 1973 and 1998 on the Galápagos Islands. The graphs below show the mean beak size in each year from 1973 to 1998 compared with the long-term mean size.



Peter R Grant and Rosemary B Grant, "Unpredictable Evolution in a 30-Year Study of Darwin's Finches", *Science*, Vol. 296 no. 5568, pp. 707--711, 26 April 2002. Reprinted with permission from AAAS.

(a) State the year in which *G. fortis* had the greatest change in relative beak size. *[1]*

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(This question continues on the following page)

(Question D1 continued)

(b) Compare the trends in relative beak size of *G. fortis* and *G. scandens*. *[3]*

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(c) Outline possible reasons for the trends in relative beak size in finches. *[2]*

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D2. The diagram below shows the apparatus used by Miller and Urey to simulate the atmosphere of early Earth.

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(a) (i) State **two** substances, other than water, that were added to the spark chamber. *[1]*

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(This question continues on the following page)

(Question D2 continued)

(ii) Outline the result of Miller and Urey's experiment. *[1]*

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(b) Outline the correlation between the change in diet and the change in brain size during hominid evolution. *[3]*

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(c) Compare convergent and divergent evolution. *[3]*

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D3. Discuss the relationship between cladograms and the classification of living organisms. *[6]*

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will not be marked.

Option E — Neurobiology and behaviour

E1. Many marine invertebrates must swim or move in currents until they find a suitable habitat in which to settle. A laboratory experiment was conducted to determine the swimming response of blue crab (*Callinectes sapidus*) larvae to water flowing at different velocities in a sea water column. The graphs below show the results for water flow velocity at $0\,cm\,s^{-1}$, $3.6\,cm\,s^{-1}$ and $6.3\,cm\,s^{-1}$. Positive values indicate movement in the direction of the current and negative values indicate movement against the current.

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(This question continues on the following page)

(Question E1 continued)

(a) State the maximum net swimming velocity observed, giving the units. *[1]*

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(b) Calculate the percentage of *C. sapidus* larvae that swam against the current when the water flow velocity was $3.6\,cm\,s^{-1}$. *[1]*

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(c) Compare the swimming of the *C. sapidus* larvae at the different water flow velocities. *[2]*

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(d) The hypothesis was made that *C. sapidus* larvae are able to actively move in any direction to find suitable sites in which to settle. Analyse the data to determine if it supports this hypothesis. *[2]*

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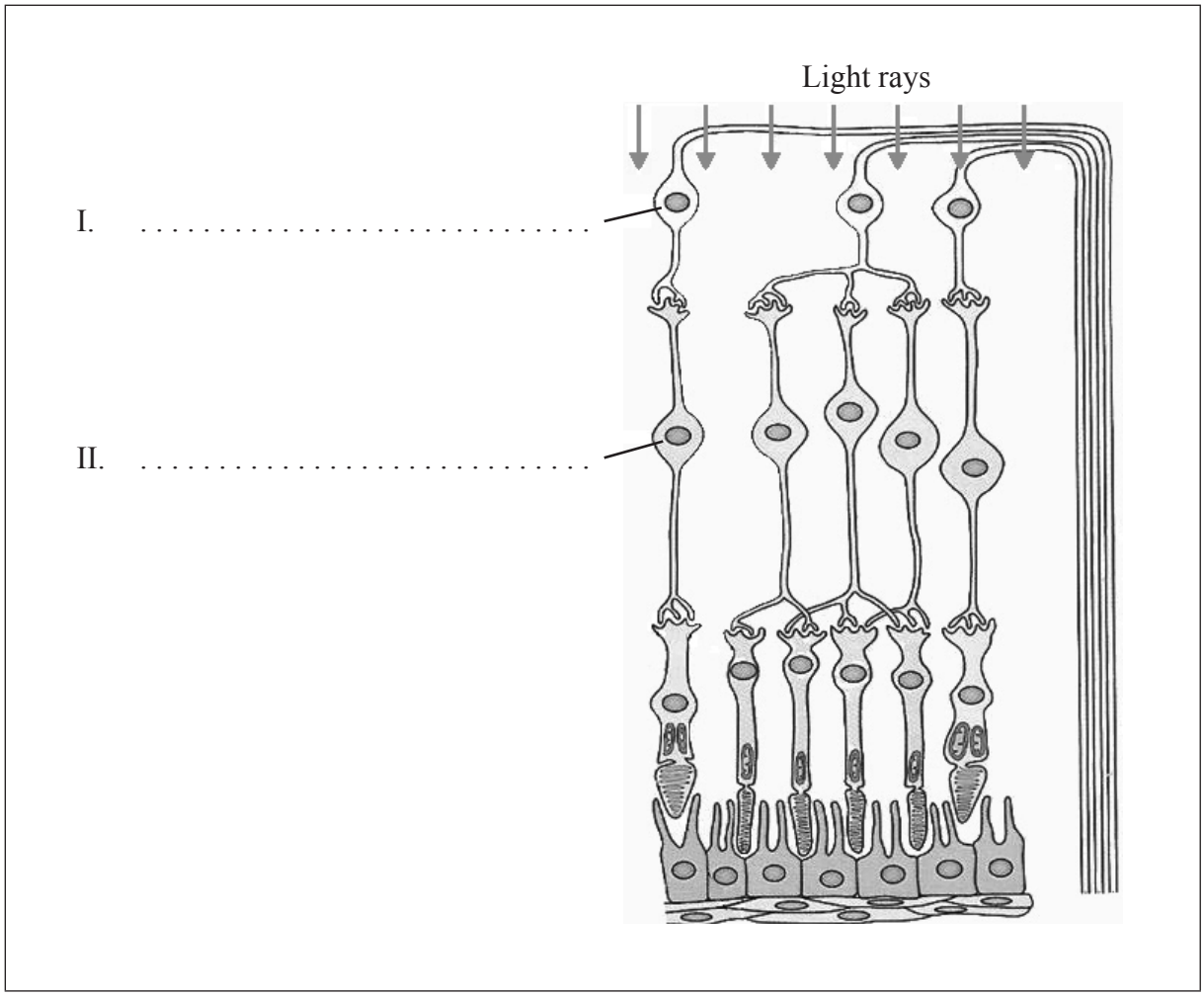
E2. (a) (i) The diagram below shows the structure of the retina. Label I and II. *[1]*



C. J. Clegg, *Introduction to Advanced Biology*, 2000, p. 285. Reproduced by permission of Hodder Education.

(ii) Distinguish between rods and cones. *[2]*

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(Question E2 continued)

(b) Outline the pupil reflex. *[2]*

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(c) Discuss the use of the pupil reflex in testing for brain death. *[3]*

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E3. Discuss the evolution of altruistic behaviour using **one** non-human example. *[6]*

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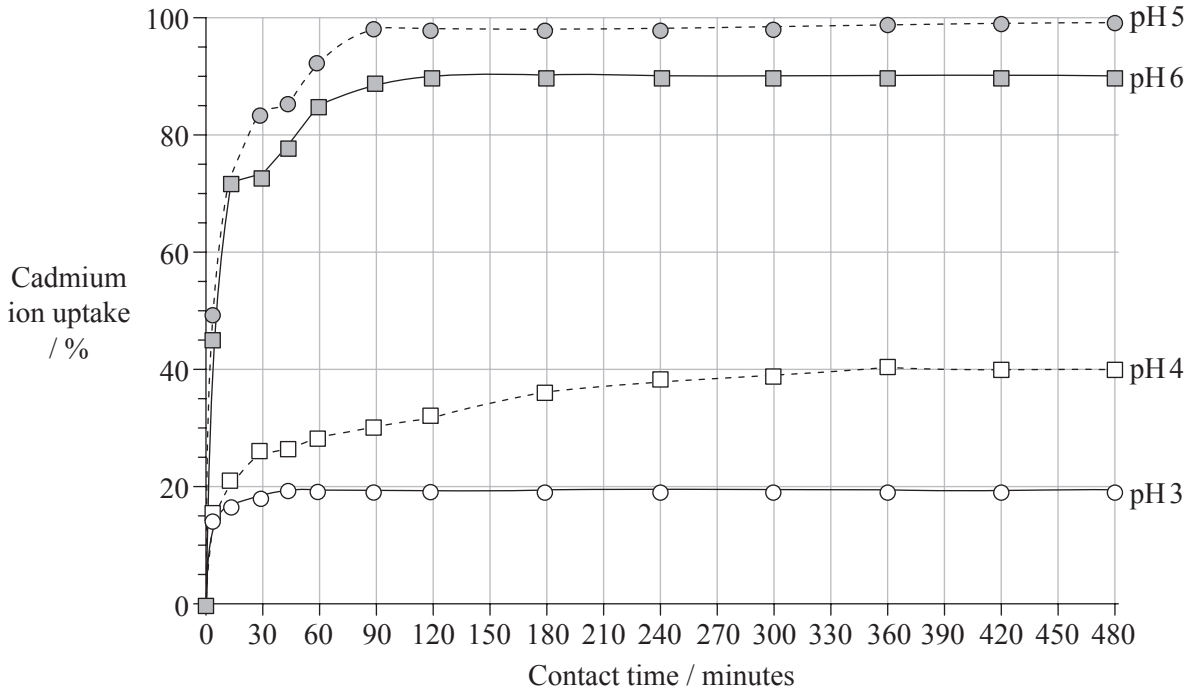
Option F — Microbes and biotechnology

F1. Removal of toxic heavy metals from industrial waste water is essential in order to control environmental pollution. Industrial waste water near Yanbu City, Saudi Arabia was found to contain 19 species of microorganisms that could tolerate heavy metals. The accumulation of cadmium ions in the most common of these microorganisms, *Aspergillus fumigatus*, was investigated.

The graph below shows the effect of pH on the ability of *A. fumigatus* to absorb cadmium ions from an aqueous solution.



[Source: adapted from S Al-Garni, *et al*., (2009), *African Journal of Biotechnology*, **8** (17), pages 4163–4172]

(a) Describe the cadmium ion uptake by *A. fumigatus* at pH 6. *[2]*

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(This question continues on the following page)

(Question F1 continued)

(b) Calculate the difference in cadmium ion uptake between pH 4 and pH 5 at 60 minutes. *[1]*

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(c) Discuss the use of *A. fumigatus* for the removal of cadmium ions in polluted waters. *[2]*

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(d) The investigation found that both living and dead *A. fumigatus* cells were able to absorb cadmium ions. Suggest an advantage of using dead *A. fumigatus* cells. *[1]*

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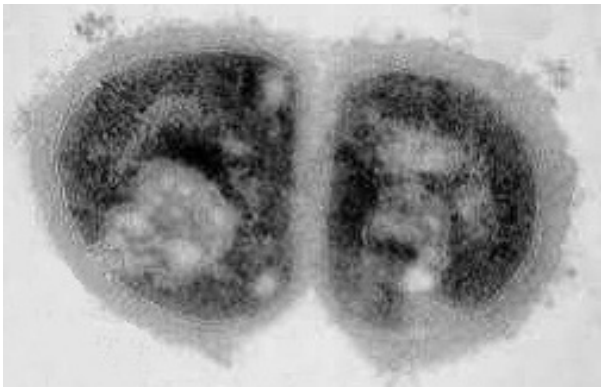
F2. (a) The electron micrograph below shows a thin section of the Gram-positive bacterium *Micrococcus lysodeikticus*.



(i) Compare the cell wall structure of this bacterium with one classified as Gram-negative. *[2]*

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(ii) *M. lysodeikticus* is a chemoheterotroph. Define the term *chemoheterotroph*. *[1]*

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(b) Outline the role of saprotrophic bacteria in the treatment of sewage using reed bed systems. *[2]*

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(Question F2 continued)

(c) Distinguish between bacterial infections caused by *Chlamydia* and *Streptococcus*. *[3]*

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F3. Discuss the use of viral vectors in gene therapy including the risks involved. *[6]*

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will not be marked.

Option G — Ecology and conservation

G1. The impact on ecosystems of the loss of large herbivore species was studied by looking at plant communities in two similar grassland ecosystems in South Africa (Kruger National Park) and North America (Konza, Kansas). Some sites had large herbivore species present and at other sites they were absent. The main herbivores were Cape buffalo (*Syncerus caffer*) in South Africa and bison (*Bos bison*) in North America. The herbaceous plants identified were grouped as either grass or non-grass.

The table shows plant abundance and diversity in Kruger National Park and Konza, Kansas.

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(a) At Konza, grass abundance was 4.4 units greater in areas where there was a single large herbivore species than in areas where there was no large herbivore species.

(i) Calculate the difference in non-grass abundance between areas with and without a large herbivore species at Konza. *[1]*

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(This question continues on the following page)

(Question G1 continued)

(ii) Identify if the trend shown at Konza is the same at Kruger. *[1]*

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(iii) Suggest a possible reason for the difference in changes of grass and non-grass abundance. *[1]*

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(b) Compare plant species diversity at Kruger and Konza. *[2]*

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(c) Evaluate the data to determine if a single large herbivore species **or** multiple large herbivore species are better for grassland plant community abundance and diversity. *[2]*

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G2. In 1988 a fire destroyed large portions of forest in Yellowstone National Park, USA. Photograph A was taken soon after the fire and photograph B one year later. The photographs are of the same area.

Photograph A

[Source: http://commons.wikimedia.org/wiki/File:Grass_growing_after_fire.jpg, created by National Park service employee.]

Photograph B

[Source: http://commons.wikimedia.org/wiki/File:Flowers_Yellowstone_1989.jpg, created by National Park service employee.]

(a) Identify, with a reason, the type of succession that has taken place. *[1]*

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(b) State the main characteristics of a temperate deciduous forest. *[1]*

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(Question G2 continued)

(c) Outline a method that could be used to sample the plant population shown in photograph B. *[2]*

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(d) Yellowstone National Park was the first national park in the world and is a designated biosphere reserve site. Outline the biogeographical features of nature reserves that promote conservation of diversity. *[3]*

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G3. Discuss international measures that would promote the conservation of fish stocks. *[6]*

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Option H — Further human physiology

H1. People who are born at high altitude in mountainous regions and continue to live there are known as highlanders. The heart and pulmonary circulation of healthy highlanders show important physiological and anatomical characteristics. However, chronic mountain sickness (CMS) is a health problem in mountainous regions around the world.

The graph below shows the relationship between pulmonary artery pressure (P_{PA}) and arterial oxygen saturation (Sa_{O_2}) in healthy highlanders and those with chronic mountain sickness in Peru. The mean values are shown for these groups and also for people who live at sea level.

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(a) State the relationship between pulmonary artery pressure (P_{PA}) and arterial oxygen saturation (Sa_{O_2}). *[1]*

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(Question H1 continued)

(b) Calculate the difference in mean arterial oxygen saturation $\left(Sa_{O_2}\right)$ between healthy highlanders and sea level residents, giving the units. *[1]*

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(c) Compare the pulmonary artery pressure $\left(P_{PA}\right)$ of healthy highlanders with the pulmonary artery pressure $\left(P_{PA}\right)$ of highlanders with chronic mountain sickness (CMS). *[3]*

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(d) Using the data, suggest a possible symptom of chronic mountain sickness (CMS). *[1]*

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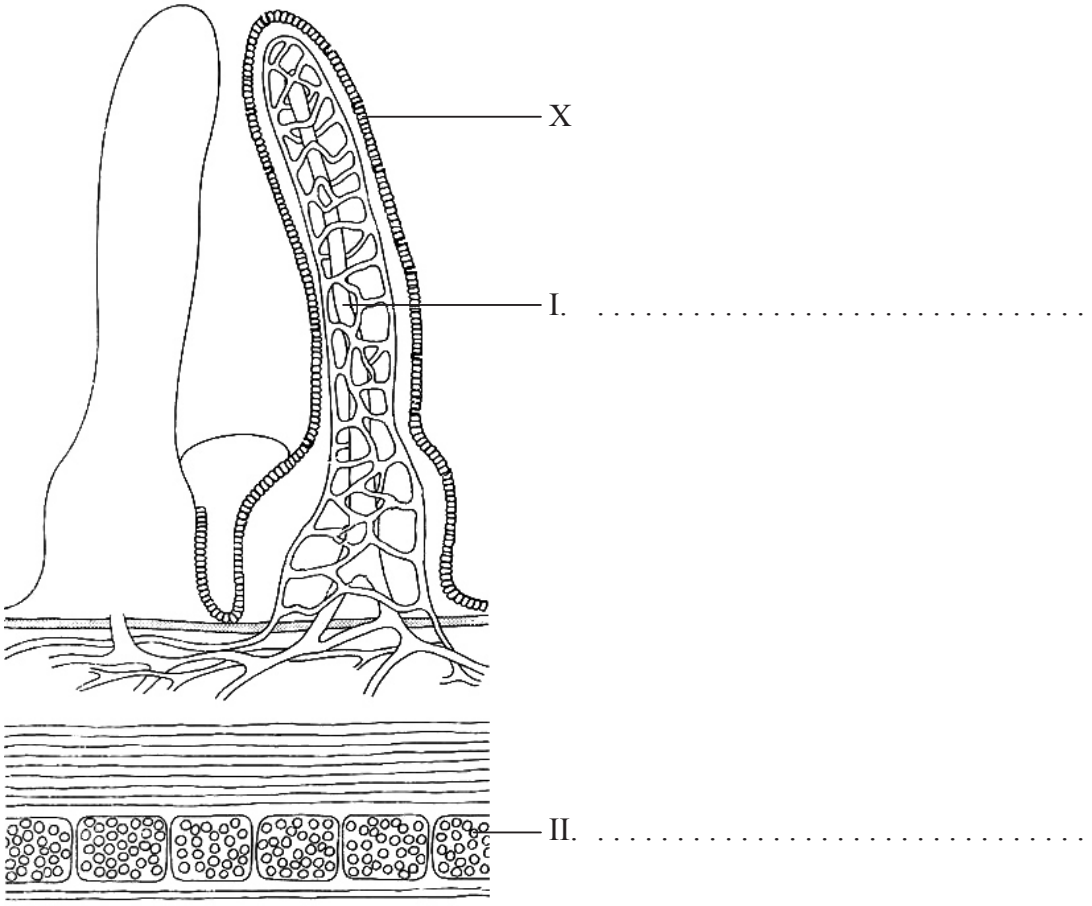
H2. (a) (i) The diagram below shows a section through the ileum. Label I and II. *[1]*



Roland Soper, Nigel P. O. Green, G. Wilfred Stout and Dennis J. Taylor, *Biological Science*, 1990, p. 316, Cambridge University Press. Used with permission.

(ii) Outline **two** important structural features of cell X. *[2]*

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(Question H2 continued)

(b) Explain the role of bile in lipid digestion. *[2]*

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(c) Explain why trypsin is initially synthesized as an inactive precursor and how it is activated. *[3]*

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H3. Describe the control of ADH secretion. *[6]*

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